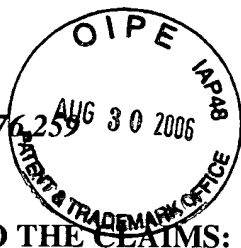


KUBOSHIMA et al.

Application No. 10/676,259

August 30, 2006



AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application:

1.-2. (canceled)

3. (previously presented) An exhaust gas cleaning system for an internal combustion engine, the system comprising:

an exhaust gas after-treatment device disposed in an exhaust passage of the engine;

an outlet gas temperature sensing means for sensing outlet gas temperature of exhaust gas downstream of the exhaust gas after-treatment device;

temperature estimating means for calculating estimated temperature of the exhaust gas after-treatment device from an output of the outlet gas temperature sensing means with the use of an inverse transfer function of a change in the outlet gas temperature with respect to a change in the temperature of the exhaust gas after-treatment device; and

state detecting means for determining whether the exhaust gas after-treatment device is in a predetermined state, based on the estimated temperature calculated by the temperature estimating means;

wherein the temperature estimating means uses the inverse transfer function expressed with first-order lag and dead time;

wherein the temperature estimating means changes a time constant of the first-order lag and the dead time respectively in accordance with a flow rate of the exhaust

gas.

4. (original) The exhaust gas cleaning system as in claim 3, wherein the temperature estimating means decreases the time constant of the first-order lag and the dead time respectively as the flow rate of the exhaust gas increases.

5.-7. (canceled)

8. (previously presented) An exhaust gas cleaning system for an internal combustion engine, the system comprising:

an exhaust gas after-treatment device disposed in an exhaust passage of the engine;

an inlet gas temperature sensor for sensing inlet gas temperature of exhaust gas upstream of the exhaust gas after-treatment device;

an outlet gas temperature sensor for sensing outlet gas temperature of the exhaust gas downstream of the exhaust gas after-treatment device;

first temperature estimating means for calculating first estimated temperature of the exhaust gas after-treatment device from an output of the inlet gas temperature sensor with the use of a transfer function of a change in the temperature of the exhaust gas after-treatment device with respect to a change in the inlet gas temperature;

second temperature estimating means for calculating second estimated temperature of the exhaust gas after-treatment device from an output of the outlet gas temperature sensor with the use of an inverse transfer function of a change in the outlet

gas temperature with respect to the change in the temperature of the exhaust gas after-treatment device;

state detecting means for determining whether the exhaust gas after-treatment device is in a predetermined state, based on the first estimated temperature calculated by the first temperature estimating means and the second estimated temperature calculated by the second temperature estimating means;

wherein the first temperature estimating means uses the transfer function expressed with first-order lag and first dead time;

the second temperature estimating means uses the inverse transfer function expressed with first-order lag and second dead time; and

the first temperature estimating means changes a first time constant of the first-order lag and the first dead time respectively in accordance with a flow rate of the exhaust gas, and the second temperature estimating means changes a second time constant of the first-order lag and the second dead time respectively in accordance with the flow rate of the exhaust gas.

9. (original) The exhaust gas cleaning system as in claim 8, wherein the first temperature estimating means decreases the first time constant of the first-order lag and the first dead time respectively as the flow rate of the exhaust gas increases, and

the second temperature estimating means decreases the second time constant of the first-order lag and the second dead time respectively as the flow rate of the exhaust gas increases.

10. (currently amended) The exhaust gas cleaning system as in claim 68, further comprising:

a catalyst supported on a surface of the exhaust gas after-treatment device, wherein

the first estimated temperature of the exhaust gas after-treatment device is free from effect of reaction heat generated by the catalyst, and

the second estimated temperature of the exhaust gas after-treatment device reflects the effect of the reaction heat generated by the catalyst.

11. (original) The exhaust gas cleaning system as in claim 10, wherein the state detecting means includes degradation determining means for determining that the catalyst is degraded when a difference between the first estimated temperature and the second estimated temperature is smaller than a predetermined value.

12. (original) The exhaust gas cleaning system as in claim 11, wherein the state detecting means determines the predetermined value in accordance with an operating state of the engine.

13. (currently amended) An exhaust gas cleaning system for an internal combustion engine, the system comprising:

an exhaust gas after-treatment device disposed in an exhaust passage of the engine;

an inlet gas temperature sensor for sensing inlet gas temperature of exhaust gas

upstream of the exhaust gas after-treatment device;

an outlet gas temperature sensor for sensing outlet gas temperature of the exhaust gas downstream of the exhaust gas after-treatment device;

first temperature estimating means for calculating first estimated central temperature of the exhaust gas after-treatment device from an output of the inlet gas temperature sensor with the use of a transfer function of a change in the temperature of the exhaust gas after-treatment device with respect to a change in the inlet gas temperature;

second temperature estimating means for calculating second estimated central temperature of the exhaust gas after-treatment device from an output of the outlet gas temperature sensor with the use of an inverse transfer function of a change in the outlet gas temperature with respect to the change in the temperature of the exhaust gas after-treatment device;

state detecting means for determining whether the exhaust gas after-treatment device is in a predetermined state, based on the first estimated central temperature calculated by the first temperature estimating means and the second estimated central temperature calculated by the second temperature estimating means;

a catalyst supported on a surface of the exhaust gas after-treatment device, wherein

the first estimated temperature of the exhaust gas after-treatment device is free from effect of reaction heat generated by the catalyst;

the second estimated temperature of the exhaust gas after-treatment device reflects the effect of the reaction heat generated by the catalyst;

the state detecting means includes degradation determining means for determining that the catalyst is degraded when a difference between the first estimated temperature and the second estimated temperature is smaller than a predetermined value; and

~~The exhaust gas cleaning system as in claim 11, wherein the state detecting means~~
performs the determination of the degradation of the catalyst only when the outlet gas temperature sensed by the outlet gas temperature sensor is equal to or higher than activation temperature of the catalyst.

14.-16. (canceled)

17. (currently amended) A method of cleaning exhaust gas in an internal combustion engine, the method comprising:

sensing an outlet gas temperature of exhaust gas downstream of an exhaust gas after-treatment device disposed in an exhaust passage of the engine;

calculating an estimated central temperature of the exhaust gas after-treatment device based on the sensed outlet gas temperature and an inverse transfer function of a change in the outlet gas temperature with respect to a change in the temperature of the exhaust gas after-treatment device; and

determining whether the exhaust gas after-treatment device is in a predetermined state, based on the calculated estimated central temperature;

wherein the inverse transfer function is expressed with first-order lag and dead time; and

~~The method as in claim 16, wherein a time constant of the first-order lag and the dead time are respectively changed in accordance with a flow rate of the exhaust gas.~~

18. (previously presented) The method as in claim 17, wherein the time constant of the first-order lag and the dead time are respectively decreased as the flow rate of the exhaust gas increases.

19.-21. (canceled)

22. (currently amended) A method of cleaning exhaust gas in an internal combustion engine, the method comprising:

sensing an inlet gas temperature of exhaust gas upstream of an exhaust gas after-treatment device disposed in an exhaust passage of the engine;

sensing an outlet gas temperature of exhaust gas downstream of the exhaust gas after-treatment device;

calculating a first estimated central temperature of the exhaust gas after-treatment device based on the inlet gas temperature sensor and a transfer function of a change in the temperature of the exhaust gas after-treatment device with respect to a change in the inlet gas temperature;

calculating a second estimated central temperature of the exhaust gas after-treatment device based on the outlet gas temperature sensor and an inverse transfer function of a change in the outlet gas temperature with respect to the change in the temperature of the exhaust gas after-treatment device; and

determining whether the exhaust gas after-treatment device is in a predetermined state, based on the calculated first estimated central temperature and the calculated second estimated central temperature;

wherein the transfer function is expressed with first-order lag and first dead time, and the inverse transfer function is expressed with first-order lag and second dead time;
and

~~The method as in claim 21, wherein~~ the first time constant of the first-order lag and the first dead time are changed respectively in accordance with a flow rate of the exhaust gas, and the second time constant of the first-order lag and the second dead time are changed respectively in accordance with the flow rate of the exhaust gas.

23. (previously presented) The method as in claim 22, wherein the first time constant of the first-order lag and the first dead time are decreased respectively as the flow rate of the exhaust gas increases, and the second time constant of the first-order lag and the second dead time are decreased respectively as the flow rate of the exhaust gas increases.

24. (currently amended) A method of cleaning exhaust gas in an internal combustion engine, the method comprising:

sensing an inlet gas temperature of exhaust gas upstream of an exhaust gas after-treatment device disposed in an exhaust passage of the engine;

sensing an outlet gas temperature of exhaust gas downstream of the exhaust gas after-treatment device;

calculating a first estimated central temperature of the exhaust gas after-treatment device based on the inlet gas temperature sensor and a transfer function of a change in the temperature of the exhaust gas after-treatment device with respect to a change in the inlet gas temperature;

calculating a second estimated central temperature of the exhaust gas after-treatment device based on the outlet gas temperature sensor and an inverse transfer function of a change in the outlet gas temperature with respect to the change in the temperature of the exhaust gas after-treatment device;

determining whether the exhaust gas after-treatment device is in a predetermined state, based on the calculated first estimated central temperature and the calculated second estimated central temperature; and

~~The method as in claim 20, further comprising:~~

providing a catalyst supported on a surface of the exhaust gas after-treatment device, wherein the first estimated central temperature of the exhaust gas after-treatment device is free from effect of reaction heat generated by the catalyst, and the second estimated central temperature of the exhaust gas after-treatment device reflects the effect of the reaction heat generated by the catalyst.

25. (previously presented) The method as in claim 24, wherein a determination is made that the catalyst is degraded when a difference between the first estimated central temperature and the second estimated central temperature is smaller than a predetermined value.

26. (previously presented) The method as in claim 25, wherein the predetermined value is determined in accordance with an operating state of the engine.

27. (previously presented) The method as in claim 25, wherein the degradation of the catalyst is determined only when the sensed outlet gas temperature is equal to or higher than an activation temperature of the catalyst.